

SAM 10 2014

ISSN: 0804-6824

April 2014

Discussion paper

THE EARLY HISTORY OF ENVIRONMENTAL ECONOMICS

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THE EARLY HISTORY OF ENVIRONMENTAL ECONOMICS

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Abstract

This paper considers economists' treatment of problems related to the environment prior to the establishment of environmental economics as a separate field in the 1960s. In discussing the literature from the late 18th century onwards, it looks on the one hand for awareness in the work of the early economists of the effects of economic activity on the natural and social environment and of the feedback from the environment to the economy. On the other hand, it describes how economic theory developed in a way which made it increasingly relevant for the study of environmental issues and the design of economic policy.

JEL Classification: B00, Q30, Q50.

Keywords: History of thought, environment, natural resources.

*This article is based on a plenary lecture given at the 20th Annual Congress of the European Association of Environmental and Resource Economists (EAERE) in Toulouse, June 2013. I am grateful to Nicolas Treich for inviting me to speak on this topic and to a number of participants in the Congress who gave me helpful comments and suggestions. I am also indebted to a referee for constructive remarks.

1. Introduction

Environmental economics¹ is a relatively new field of specialization in economics: Many writers, e. g. Pearce (2002), locate its beginnings to the 1960s. It is a fact that it was at this time that the term “environmental economics” gradually came to be used in the titles of books and articles, over time leading to the establishment of journals, conferences and academic associations. But as my title indicates, the topic of the present article is the earlier literature to which we can trace the beginnings of environmental economics proper, and I will in fact be going back more than two centuries in time. I could conceivably have called my paper “The Prehistory of Environmental Economics,” if it were not for the fact that the term prehistory usually refers to a time before the existence of written sources. There are indeed a number of contributions that are relevant for the economic analysis of environmental problems in the writings of economists in the eighteenth, nineteenth and early twentieth centuries, and my objective is to extract some interesting perspectives from a selection of these. I can make no claim to complete coverage of the early literature. This is a difficult aim to achieve in any type of survey, and especially when the area to be surveyed had not at the time to be considered achieved the status of a reasonably separate and well-defined field.

Why should we as modern and forward-looking environmental economists take an interest in our early history? Some of us think that the history of thought is intrinsically interesting and does not need any further excuses to spend time on it. For those who need a more instrumental justification for devoting attention to the older literature, one may argue that it serves to give us a broader perspective on our current concerns and perhaps influence our

¹ Under the heading of environmental economics I also include the economics of natural resources. Although it is true that some parts of natural resource economics do not have a clear focus on the environment, historically as well as scientifically the two areas belong together.

research priorities in a positive way. I hope that the present paper will be of some relevance for the creation of such a perspective.

2. The beginnings: An eighteenth century forerunner

It is always difficult to choose a beginning for a survey of the history of ideas. If you search hard, you will almost invariably find that every important writer has had some interesting predecessor or at least that there is some other author or authors that have influenced him in a significant way. Nevertheless, one has to begin somewhere, and I begin in France with a writer that most economists know from a completely different field. The Marquis de Condorcet is famous chiefly for his formulation of the paradox of voting which demonstrated, about two centuries before Kenneth Arrow's impossibility theorem, the possible irrationality of group decision making by majority voting. But thanks to the work of Emma Rothschild (2001) we now know that his economic interests were much broader, and that we can find in it some interesting signs of the awareness of the link between economic activity and environmental quality.

Condorcet may be seen as a pioneer in the use of externality arguments in the context of the policy analysis of environmental issues. Thus, he argued that although private property rights should in principle be respected, there was a case for government interference when the exercise of property rights by one individual violated the rights of others. An example is when agricultural activities "by corrupting the air, causes illnesses in neighbouring homes."² In this case, the government would be justified in forbidding the activity that causes harm to the environment or in undertaking public works with a view to "restore the salubrity of

² This and the following quotations from Condorcet's 1776 book *Réflexions sur le commerce des blés* are taken from the translations in Rothschild (2001), pp. 172-173. This book also gives further references to his work. Much of Condorcet's writing was in fact not published during his lifetime and only appeared in print with the publication of the *Oeuvres de Condorcet* in 1847-1849, more than half a century after his death in 1794.

the air.” A related example is when the establishment of a factory in a town reduces air quality for the existing residents. In that case the government can forbid the factory owners to build the factory, and this is not in Condorcet’s view to be considered an illegitimate violation of the property rights of the factory’s owners. It is of some interest to note that Condorcet poses the choice of policy as either allowing or forbidding the activity in question; using more subtle policy instruments such as taxes or subsidies was not yet on the agenda. Condorcet based his recommendation of public interference with private property rights on the concern for social justice, not efficiency. It is unjust, he argues, that the value of individual properties should be reduced by economic activities of others that impair the quality of the environment³. However, government interference should only take place when the harm to others could be clearly and convincingly documented; if it could not, this type of argument would be open to misuse. A further point of interest is that Condorcet saw environmental pollution not only as a reason for the state to intervene in the market mechanism and restrict individual property rights but also for government encouragement of research with a view to develop cleaner technologies.

Since much of Condorcet’s work was for long unpublished and little known, he can hardly be considered to have been an important influence on the development of environmental economics. But the new awareness of his contribution that has emerged especially through the work of Rothschild shows that there was an understanding of the links between economic activity and environmental quality as early as the end of the 18th century, which is much earlier than the impression given in the bulk of the environmental economics literature. It is striking that Condorcet’s ideas were evidently inspired by factual observation,

³ This line of argument carries weight even today. In modern discussions of the polluters pay principle many people find the argument that justice calls for polluters to pay for the damage they do more persuasive than that they should be faced with incentives designed to promote efficiency.

not primarily by abstract reasoning. Observations of this kind must also have been made by others who thought systematically about economic and social questions at this time, so that one may wonder how it came to take such a long time for these problems to be brought to the forefront of economics and social science. One reason may have been that the problems were not seen as empirically very important; also, economists in particular may have thought that at best these issues belonged to the periphery of their science. If so, these were attitudes that did not die with the close of the 18th century.

3. The classical school: From Smith to Mill

By the classical school of economics one usually refers to the economists from Adam Smith to John Stuart Mill. These economists were mainly English and Scottish, although they also had some prominent followers in other countries (like Jean-Baptiste Say in France).

Historians of economic thought have generally regarded this group as the founders of modern economics, although they too built on the work of previous thinkers. Regarding their basic microeconomic approach, they laid the foundations for the neoclassical theory of price formation. In addition, Adam Smith is famous for his theory of the invisible hand which claimed⁴ that individuals who pursued their self-interest within the framework of competitive markets acted so as to promote “the publick interest.” This proposition gave the impetus to a long process of theoretical clarification that led to the modern theory of welfare economics. Together, these were indispensable tools for the analysis of market failure that later became central for environmental economics. Moreover, Smith not only understood the ability of the market mechanism to allocate private goods efficiently; he also

⁴ For a fuller discussion of the doctrine of the invisible hand and alternative interpretations of Smith’s formulations the reader may consult Sandmo (2011), Chapter 3.

realized that there are goods for which the market system does not function well and therefore has to be provided through government action. This consists in

“erecting and maintaining certain public works and certain public institutions which it can never be for the interest of any individual, or small number of individuals to erect and maintain; because the profit would never repay the expence to any individual or small number of individuals, though it may frequently do much more than repay it to a great society.” (Smith 1776; 1976, pp. 687-688.)

Apart from passages such as this, however, in the main works of the early classical economists, Adam Smith and David Ricardo (1817), we search in vain for any explicit mention of concrete environmental issues in the context of the provision of public goods. Why is this? On the one hand it is reasonable to assume that the process of industrialization and urbanization had still not progressed far enough for social thinkers to realize the magnitude of its effects on the physical environment. On the other hand, environmental issues were not yet seen as belonging to the aspects of social development that economists were expected to take an interest in.

There is, however, one member of the classical school whose fame rests on a theory where the physical environment plays a major role as a constraint on economic development. Thomas Robert Malthus' theory of population (Malthus 1798) implied that the natural tendency of population to increase exponentially was held back by decreasing returns in agriculture. In the long run population could only increase in step with the expansion of agricultural output. The long run equilibrium level of wages would correspond to the subsistence level, for if in the short run population were to increase at a faster pace than

that which was consistent with the long-run sustainable level, this would unleash forces that would check it, such as

“... unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common diseases and epidemics, wars, pestilence, plague, and famine.” (Malthus 1798; 1992, p. 23.)

This may not be environmental economics as we conceive of it today. Nevertheless, there is an awareness here of the feedback from the physical and man-made environment to human productivity and the standard of living which clearly foreshadows present concerns. In addition to pronouncements of this kind, there is in Malthus’ general model of population dynamics a structure which has wider implications and which inspired later economists to grapple with the issue of resource scarcity and economic growth.

David Ricardo, in his *Principles of Political Economy and Taxation* (1817), accepted Malthus’ theory of population but gave main emphasis to another aspect of the connection between the natural environment and the standard of living. His theory of the rent of land was based on the assumption that agricultural land varied in terms of fertility. As the demand for agricultural produce (“corn”) expands, land of successively lower fertility is brought into use, and the price of corn is determined by the cost of production on the least fertile land⁵. Since corn is of uniform quality, this means that corn from the more fertile land is sold at a price in excess of its cost of production, and this excess is the land rent. As the population and work force increase, the demand for corn also increases, and the extension of the margin of

⁵ On the one hand, this conclusion was consistent with the classical cost of production theory of value. On the other hand, with its emphasis on increasing unit costs of production for agriculture as a whole, it predates the insights of the marginalist school whose breakthrough came several decades later.

cultivation leads to an increase of rental income. With a constant level of wage income this leads to a declining rate of profit. The result is a weakening of the incentive to invest and an end to the growth process in the form of the stationary state.

Ricardo also considered the extension of his theory of rent to the mining industry, but his discussion of this is not carried very far. After having remarked that the theory of rent that applies to mines is essentially the same as that which applies to agriculture, he goes on to discuss the implications of the increasing cost of precious metals for the monetary standard. He does not consider the growth implications of a possible scarcity of exhaustible resources.

As we know, the theory of rent regarding both agriculture and mining became of great importance for the further development of environmental economics. The same is true regarding the classical economists' notion of the stationary state which found an echo much later in the heated debates about the limits to growth.

The classical school of economics is usually seen as ending with John Stuart Mill. His *Principles of Political Economy* (1848) represents a consolidation of the classical approach while at the same time it broke new ground in a number of ways, both analytically and in broadening the scope of economic analysis. An example of the latter appears in his discussion of the duties and limits of government which reflects Mill's interesting profile both as a market liberalist and a social reformer. Having made a distinction between the necessary and optional tasks of the government, Mill points out that the former are in fact much more extensive than many are inclined to admit. The adherents of a minimal state argue that its necessary tasks are to protect the country against external enemies and secure the life and property of its people. However, Mill argues, there are a number of tasks that follow from this and which are easily overlooked. The role of the state in protecting

ownership may be given either a narrow or a broad interpretation. The narrow interpretation implies that the state should secure the right of each individual to what he himself has produced or legitimately acquired from others. But this is not the only kind of property that needs the protection of government. For

“[i]s there not the earth itself, its forests and waters, and all other natural riches, above and below the surface? These are the inheritance of the human race, and there must be regulations for the common enjoyment of it. What rights, and under what conditions, a person shall be allowed to exercise over any portion of this common inheritance cannot be left undecided. No function of government is less optional than the regulation of these things, or more completely involved in the idea of civilized society.” (Mill 1848; 1965, p. 801.)

In modern terminology, Mill emphasizes the public good nature of the natural environment and points out that the management of this cannot be left to market forces and individual action.

With regard to the form that government action should adopt in undertaking this supplementary role in the allocation of resources, Mill is less than specific. In spite of his positive view of the contribution that public policy can make to environmental public goods, he is also skeptical to the ability of the state to act in a more intelligent way than the market. He therefore argues that it is not a sufficient argument for government intervention that the *laissez-faire* allocation is imperfect; there must be reason to believe that government action, given its own imperfections, will actually improve on the outcome.

Although Mill did not attempt a systematic application of the tools of economic analysis to problems of the environment, on several occasions he expressed himself strongly in favour

of the preservation of the natural environment, as e.g. in his extensive correspondence with influential individuals and institutions. Thus, in a letter to the secretary of the Commons Preservation Society in 1866, he said that

“I have all my life been strongly impressed with the importance of preserving as much as possible of such free space for healthful exercise, & for the enjoyment of natural beauty as the growth of population and cultivation has still left to us. The desire to engross the whole surface of the earth in the mere production of the greatest possible quantity of food & the materials of manufacture, I consider to be founded on a mischievously narrow conception of the requirements of human nature.” (Mill 1972, pp. 1140-1141.)

In another letter, written a few years later, he commented on the desire by the Land and Labour League, an organization with strong ties to the labour movement, to convert large areas of waste land to farming:

“I should be sorry to see the whole of these farmed out & given up to cultivation. I wish a great part of them to remain in their native wildness & natural beauty. There is little enough beauty in our common life, & we cannot afford to sacrifice what we have.” (Mill 1972, p. 1651.)

He was worried about the lack of political support for the preservation of the natural commons but remarked to one of his correspondents that

“[w]omen’s suffrage will help us in this as in so many other things, for women will be much more unwilling than men to submit to the expulsion of all beauty from common life.” (Mill 1972, p. 1659.)

Both in the writings of Mill and some of the other classical economists there is interesting evidence of a beginning consciousness of the environmental problems that modern industrial civilization created, and also of a realization that public policy, if carried out intelligently, could improve on the market outcome. However, the state of economic theory at the time made it difficult to pinpoint the sources of market failure and to deduce the appropriate design of public policies that would ensure economic and social improvement.

The history of economic thought should of course stick to the facts and shy away from hypothetical questions of what might have been. Nevertheless, it is tempting to speculate about what might have happened if Cournot, whose 1838 book on the mathematical formulation of price theory (Cournot 1838) was in several respects more advanced than the analysis of even the later marginalists, had got together with his countryman Dupuit, whose articles on cost-benefit analysis and public sector pricing (Dupuit 1844, 1849) laid the foundation for normative public finance. Together, they could have merged their areas of expertise and started to apply partial equilibrium theory to the problems of externalities and public sector pricing several decades before this actually happened.

4. Theory and applications: Edwin Chadwick

The theoretical analysis of the classical economists regarding the workings of the market system was obviously based on a microeconomic analysis of how individuals could best pursue their own interest in the face of given market prices – i.e. on a theory of incentives. However, the question of how this fundamental insight could be used for public sector decisions and for the implementation of social reform was not one that greatly concerned them. One who did see the possibilities for the practical exploitation of theoretical ideas was Edwin Chadwick (1800-1890), a civil servant who was much influenced by the utilitarian

philosopher Jeremy Bentham as well as by John Stuart Mill. During his long and very active career as a public administrator he made a number of important contributions to the design of policy and pioneered both in the creative design of incentive-based mechanisms and in the use of empirical data. Since historians of thought have tended to focus their attention on the development of pure theory, Chadwick has not received much attention in this literature. This has recently been rectified by the work of Robert B. Ekelund and co-authors, as in the books by Ekelund and Hébert (1997) and Ekelund and Price (2012). As an example of Chadwick's inventiveness in the exploitation of incentives for administrative improvement, it is tempting to cite his initiative regarding the transportation of British criminals to Australia. The captains of the vessels in charge of the transports were originally paid a flat fee per prisoner taken on board in the port of departure. When at Sidgwick's suggestion the scheme was changed so that the captains were paid per prisoner who disembarked alive in Australia, the survival rate among the convicts increased from 40 per cent to 98.5 per cent. The story is both depressing and encouraging. It is depressing in its cynical depiction of the attitudes of the captains. At the same time it is encouraging in showing how a clear-thinking economist may design an incentive scheme that utilizes the desire for private financial gain to achieve an improvement which is undoubtedly for the benefit of society.

One of the fields where Chadwick made a major contribution to public administration was public health and sanitation, and one area within this field that particularly concerned him was the funeral industry, or rather the two interrelated markets for funerals and burials. In a 1843 government report, he argued that the market for funerals was characterized by an inefficient structure (mainly due to high information and search costs) which caused the price of funerals to be too high. The high price caused delays which again led to a sanitation

problem. The health damage from the delays in burials was further exacerbated by the existence of widely dispersed and overcrowded private graveyards which caused the spread of fever, typhus and other diseases; Chadwick collected a very large amount of medical data to support his case. His own suggestion for reform was to make funerals and burials a government responsibility although carried out by private undertakers on the basis of franchise bidding. The Board of Health would take on the ownership and management of burial grounds, to be located outside the central metropolitan areas so as to eliminate the sanitary externalities⁶.

This is just one of the many examples of Chadwick's suggestions for exploiting private incentives for the common good in the face of externalities. Although he was not an economic theorist, his impressive ability to utilize classical price theory to the design of incentives for environmental and social improvement ought to lead to his recognition as a pioneer of environmental economics. Moreover, his extensive use of empirical data to support his analysis and policy recommendations should contribute further to his standing in the history of our discipline.

5. Natural resource scarcity: Jevons on the Coal Question

Historians of thought mainly focus on William Stanley Jevons as an economic theorist and a pioneer of marginalist thought. This focus is clearly justified by the fact that his book *The Theory of Political Economy* (Jevons 1871) was one of the major contributions to the so-called marginalist revolution. However, Jevons was as much an empirical economist as a theorist, and his empirical contributions reflect his early training in mathematics and the

⁶ Chadwick's work on these problems is described in the article by Ekelund and Ford (1997).

natural sciences. His first major empirical work was *The Coal Question* (Jevons 1865). This book caused a great stir by predicting England's demise as an industrial nation through the depletion of its coal reserves. While Jevons had been disappointed at the lack of interest in his attempt in the early 1860s to introduce the concept of marginal utility as the foundation for price theory and his advocacy of the use of mathematics in economics, this time he could not complain about the reception of his work. His gloomy prediction of the end of the era of economic progress caught the public imagination, it was discussed in Parliament, and Prime Minister Gladstone invited him to a personal conference to discuss his ideas.

The main idea in Jevons' book was that England's economic development was bound up with exponential growth in industries that were dependent on coal as a source of energy.

However, in Jevons' opinion coal could no longer be extracted at the speed that would allow this growth to continue. The lack of coal would therefore act as a brake on the country's economic growth, and it was necessary to rethink its national strategy. Jevons goes into great detail in building up his case, including an extensive discussion of the cost of coal mining and its geological foundations. There are some references to economic theory, but the absence of formal theory is more remarkable than its use. There are no references to the formal theory of supply and demand and no attempts to use the theory of the allocation of resources over time which Jevons was later to sketch in his *Theory of Political Economy*. One explanation of this may be that such a link between theory and application was not within his analytical reach; another reason was probably that since the book was aimed at a broad public, the inclusion of formal theoretical reasoning would be misplaced.

As an aside, it may be noted that Jevons links the present and future price of coal explicitly to the cost of extraction. Modern resource economists will have no difficulties in following

him on this point, but it is nevertheless remarkable that the author of *The Theory of Political Economy* should take this strong view of cost as the determinant of price. For in his later book (as well as in his earlier work) Jevons was emphatic in his view that it was marginal utility that was the basis for the understanding of price formation, not cost. A pioneer in pure theory, his grasp of its implications had still not reached the point where the new approach influenced his applied work to any significant degree.

The most interesting aspect of the book from a broader environmental economics perspective may be Jevons' connection of his analysis with Malthus' theory of population. He accepts the hypothesis that, in his own words, "living beings of the same nature and the same circumstances multiply in the same geometrical ratio"; this statement, he says, is self-evident once the meaning of the words is properly understood. He then goes on to argue that what is true of population is true of society more generally: There is a natural tendency, given that the circumstances and character of the people are the same, for the economy to grow exponentially. But at this stage, he says, we must be careful:

"We are getting to the gist of the subject. Even if we do not change in inward character, yet the aggregate of our exterior circumstances, our *environment*, as Mr. Spencer expresses it, is usually changing." (Jevons 1865; 1965, p. 194.)

The emphasis (which is in the original) is an indication that "environment" was at that time a relatively new expression, at least in an economic and social context. ("Mr. Spencer" is Herbert Spencer (1820-1903), a philosopher who believed that biological laws ought also to be applied to the study of man and society.)

The changing environment consists of the diminished supply of coal reserves, and the reduction comes about both as the result of population growth and the increase in per

capita consumption. Jevons discusses the applications of the Malthusian model to this issue and points out one difference that is of major and serious importance:

“A farm, however far pushed, will under proper cultivation continue to yield for ever a constant crop. But in a mine there is no reproduction; the produce once pushed to the utmost will soon begin to fail and sink towards zero. *So far, then, as our wealth and progress depend on the superior command of coal we must not only cease to progress as before – we must begin a retrograde career.*” (Jevons 1865; 1965, p. 201.)

An interesting question that arises from this line of argument is obviously what possibilities there are of the substitution of other sources of energy for the vanishing coal reserves. On this point Jevons is a bit vague. He does discuss the possible future role of electricity but finds it clearly inferior to coal. Speculating further, he points out that

“[a]mong the residual possibilities of unforeseen events, it is just possible that some day the sunbeams may be collected, or that some source of energy now unknown may be detected. But such a discovery would simply destroy our peculiar industrial supremacy.” (Jevons 1865; 1965, p. 190.)

Jevons does not attempt to analyze the constraints on energy supply in a global context; his concern is limited to Britain’s position – indeed mainly to its *relative* position - in the world.

There has been a tendency in the literature to downplay Jevons’ analysis of resource scarcity and to treat it as an unimportant and slightly sensational piece of writing by an economist whose historical significance lay in his contribution to pure theory. I believe that this judgment is too harsh and that *The Coal Question* should be seen as a significant contribution to the early history of environmental and resource economics.

6. Marginalism and the environment

The marginalist revolution of the 1870s, with Jevons, Carl Menger and Léon Walras as its main proponents, was concerned with improving on the economic theory of the classical economists in two main respects. One was to generalize the theory of price formation, particularly with a view to clarifying the role of demand and its foundations in the theory of utility maximization. The other was to investigate the basis of Adam Smith's contention that competitive markets brought about an allocation of resources that was in the public interest. The peak of the achievement in the work of this first generation of marginalists was Walras' *Éléments d'économie politique pure* (Walras 1874-1877) in which he worked out the general equilibrium of a competitive market economy and demonstrated that it maximized a notion of social utility which bears some resemblance to the concept of optimality which was later formulated by his successor Vilfredo Pareto. However, neither Walras nor Jevons and Menger used the competitive equilibrium model to derive conclusions about optimal policy in the case of market failure. This task was left for later generations of marginalists.

Pareto's main contribution in his *Manuel d'économie politique* (Pareto 1909) lay in showing that the conditions for the optimum allocation of resources that now bears his name were satisfied by the equations characterizing the competitive equilibrium in the absence of externalities. This was of very great importance for later work on externalities in a general equilibrium setting, although this issue was not one of Pareto's own concerns.

Simultaneously with Walras' and Pareto's work on general equilibrium, partial equilibrium theory was being developed by Alfred Marshall, in particular in his main work *Principles of Economics* (Marshall 1890). From the present viewpoint one of his great achievements was the formulation of the concept of externalities or, to use his own words, external economies

and diseconomies. The choice of words reflects the chief use that Marshall made of the concept, which was to explain a puzzle that he claimed to observe empirically, viz. that the long-run supply curve for a competitive industry was downward sloping. Since, under competitive conditions, the supply curve for the individual firm had to be upward sloping, the existence of a downward-sloping curve for the industry as a whole could be explained by positive cost externalities between firms, so that increasing output by one firm led to lower costs for others. But the externalities could also go the other way, i.e. there could be external diseconomies as well as economies. An important conclusion that followed from the analysis was that in the presence of externalities the competitive equilibrium would no longer be socially efficient; using Marshall's own concepts, the market equilibrium would no longer maximize the social surplus.

At this general level the concepts of external economies and diseconomies seem to have little to do with environmental economics. However, an example of external diseconomies that Marshall discusses in some detail and which has obvious relevance to the environment relates to the fisheries. An individual firm in the fishing industry may experience constant returns to scale; two vessels will be able to catch twice as much fish as one. However, when many firms increase their number of vessels, the stock of fish declines and vessels may have to travel further in order to catch the same amount as before. Thus, the unit cost of fishing goes up, and the private marginal cost of fishing is less than the social cost, leading the individual firms to push aggregate resource use to a point beyond the social optimum (Marshall 1890; 1920, p. 166). We may note that Marshall's conclusion regarding this issue is formulated with a degree of caution that was characteristic of his style of writing; the possibility of overfishing was a controversial issue in public debate at the time, and he clearly did not wish his illustration of a theoretical point to be understood as taking a position on a

current controversy. The example was nevertheless a pioneering effort to study the economics of a common property resource, and his conclusion about the tendency to overexploitation was of significant importance for the more general approaches to this question that were to follow.

7. Pigou and the foundations of environmental economics

The theory of externalities was developed further by Marshall's successor in Cambridge, Arthur C. Pigou. In his books *The Economics of Welfare* (1920) and *A Study in Public Finance* (1928) he made significant extensions of the scope of the theory, particularly to include externalities in consumption⁷. He also analyzed the choice of policies, particularly in the form of taxes, in order to improve the efficiency of resource allocation. In addition, he discussed the empirical measurement of environmental damage, a topic that was definitely novel in the academic literature, although it had been discussed by those engaged with public administration in this area, such as Chadwick. It is no exaggeration to claim that it was Pigou who laid the groundwork for the modern field of environmental economics.

Pigou's analysis of market failure – to use a modern expression – is based on the distinction between what he calls private and social marginal net products. The social marginal net product is less than the private marginal net product if either the social marginal benefit is less than the private marginal benefit or the social marginal cost is higher than the private marginal cost. This will be the case if there are negative external effects, and Pigou cites several examples where this is likely to be the case. Thus, a factory which emits smoke that harms consumers – an example considered in some detail in *The Economics of Welfare* –

⁷ In fact, he had begun this analysis in his *Wealth and Welfare* (Pigou 1912), a book that may be considered as an earlier version of *The Economics of Welfare*.

imposes a cost on the community in excess of that which appears in its private accounts of revenues and costs,

“... for this smoke in large towns inflicts a heavy uncharged loss on the community, in injury to buildings and vegetables, expenses for washing clothes and cleaning rooms, expenses for the provision of extra artificial lights, and in many other ways.” (Pigou 1920; 1952, p. 184.)

Hence the private marginal cost is less than the social marginal cost. By implicitly underestimating social costs the factory has an incentive to carry its activities beyond the point where there is equality between marginal social benefits and costs. This market failure can be corrected by tax policy:

“When competition rules and social and private net product at the margin diverge, it is theoretically possible to put matters right by the imposition of a tax or the grant of a subsidy.” (Pigou 1920; 1952, p. 381.)

In his *Study in Public Finance* he elaborates on this statement to claim that, when “maladjustments” exist,

“it is always possible, on the assumption that no administrative costs are involved, to correct them by imposing appropriate rates of tax on resources employed in uses that tend to be pushed too far and employing the proceeds to provide bounties, at appropriate rates, on uses of the opposite class.” (Pigou 1928; 1947, p. 99.)⁸

⁸ The last part of this quotation is a bit puzzling. It seems to suggest that tax collections and subsidy payments should somehow be in balance, whereas the main point obviously is to create the right incentives. Pigou may have wished to abstract from the second best difficulties that would arise if the net proceeds of the tax/subsidy scheme would have to be distributed or collected in a distortionary manner.

Pigou did not regard taxes and subsidies as the only solution to environmental policy problems. He also pointed out that outright prohibition of some items of production or consumption might sometimes be in order, and he suggested modifications of his proposals to be applied under non-competitive conditions. It is of some interest to note that he did not consider the establishment of property rights in environmental resources and the use of tradable permits to solve externality problems; the analysis of this set of issues belongs to the modern phase of environmental economics, beginning in the 1960s. That tax-subsidy schemes suggested themselves more naturally to Pigou is understandable, given his background in the field of public finance.

Pigou also warned against a too hasty identification of theoretical propositions with firm policy proposals:

“It is not sufficient to contrast the imperfect adjustments of unfettered private enterprise with the best adjustment that economists in their studies can imagine. For we cannot expect that any public authority will attain, or will even whole-heartedly seek, that ideal. Such authorities are liable alike to ignorance, to sectional pressure and to personal corruption by private interest.” (Pigou 1920; 1952, p. 332.)

This warning mirrors the attitude expressed by John Stuart Mill several decades earlier and also looks forward to the criticism by the public choice school of the allegedly naïve applications of welfare economics to the design of economic policy. Whether Pigou’s cautionary words were sufficiently heeded by his successors in environmental economics and public finance is a matter for debate. My personal view is that Pigou’s willingness to combine the analysis of optimal policy with a realistic attitude to the possibility of its political

implementation is one that is shared by most of those who have worked in this tradition, and that much of the public choice criticism in this respect is overdone.

Pigou also discussed possible empirical methods for assessing the benefits of environmental improvement schemes. He did not make any original contributions to this subject, but his examples related to actual empirical investigations provide a guide to his own thinking. To my mind, his most interesting example is the description of “a valuable investigation” carried out by the Manchester Air Pollution Advisory Board in 1918 (Pigou 1920; 1952, p. 185n.) This example illustrates his argument about the environmental costs of factory smoke. An investigation was made of the cost of weekly washing in the smoky town of Manchester as compared with the similar cost in the clean town of Harrogate. On the basis of cost data for 100 working class households in each town, it was found that the extra cost per household in Manchester amounted to 7 ½ pence per week. The population of Manchester was three quarters of a million, and a calculation of the cost of factory smoke to the city as a whole amounted to over £290,000 a year. This was obviously a cautious estimate; it assumed e.g. that the cost to the middle class was no greater than that of the working class, and this, as the Advisory Board pointed out, was “a considerable under-statement.” In addition, of course, the estimate was limited to just one of the components in Pigou’s list of damages of factory smoke. His point in quoting it with obvious approval must therefore have been mainly methodological; it demonstrated how one could go about using empirical data to estimate the costs of environmental deterioration.

Pigou also cites examples of positive environmental externalities where

“... private marginal net product falls short of marginal social net product, because incidental services are performed to third parties from whom it is technically difficult to exact payment.”

A case in point is of special interest to the modern environmental economist and concerns

“... resources devoted to afforestation, since the beneficial effect on climate often extends beyond the borders of the estates owned by the person responsible for the forest.” (Pigou 1920; 1952, p. 184.)

The example recalls the current debate about afforestation as an instrument in global climate policy. National governments as the “owners” of their own territories do not reap the full climate benefits from afforestation, so that global welfare maximization calls for subsidies to afforestation by national governments. What form such subsidies should take is one of the issues that are being considered in modern discussions of global climate policy.

Clearly, Pigou is a towering figure in the early history of our field. He developed Marshall’s theory of externalities into the central analytical concept for understanding market failure in the presence of environmental externalities. He demonstrated how taxes and subsidies could be used to improve on the allocation of resources in a competitive economy, and he suggested methods of empirical measurement that point forward to modern cost-benefit analysis.

8. The emergence of natural resource economics

It is in fact quite hard to pinpoint the beginnings of the economics of natural resources. The society which constituted the frame of reference for the early classical economists in the late 18th century was still primarily an agricultural economy, and the productivity of land

therefore played a prominent role in the economics of Adam Smith and his predecessors, e.g. the French physiocrats. In Malthus' theories, as we have seen, agricultural productivity was assigned a central role in his predictions of the future standard of living that the population could expect. Some decades later, Jevons emphasized the scarcity of a non-renewable resource, coal, as a constraint on the development of the British economy, while Alfred Marshall indicated the possible inefficiencies that could arise in a competitive exploitation of a common property resource. The following decades saw the development of economic analysis both in relation to renewable and exhaustible resources. I will concentrate my remarks on a few landmarks of its history⁹.

Marshall's interest in the fisheries as an example of a common property resource took some time to be followed up by other economists, and it was biologists rather than economists who in the following decades expressed concern that the organization of the fishing industry could lead to an outcome that was suboptimal from the point of view of society as a whole. The contribution that brought the fisheries to the attention of the broader economics profession was the article by Gordon (1954) which described the structure of the fishing industry, constructed a formal economic model of biological and economic equilibrium and derived conclusions for the design of economic policy. In Gordon's model there are one or more fishing stocks to which fishermen have free access and where the marginal cost of fishing effort is taken to be constant. The optimum fishing effort from society's point of view is where the value of the marginal productivity is equal to the unit cost. However, with free entry to the common property resource the equilibrium will be one where the value of the

⁹ For more detailed accounts of the history of this branch of economic theory see Robinson (1989) and Barbier (1989).

average productivity is equated to the unit cost. Since average productivity is greater than marginal productivity, the amount of fishing effort is too great; in Gordon's words,

“... the rent which the intramarginal grounds are capable of yielding is dissipated through misallocation of fishing effort.”

Gordon elaborated on this conclusion as follows:

“This is why fishermen are not wealthy, despite the fact that the fishery resources of the sea are the richest and most indestructible available to man. By and large, the only fisherman who becomes rich is one who makes a lucky catch or one who participates in a fishery that is put under a form of social control that turns the open resource into property rights.” (Gordon 1954, p. 132.)

Gordon's article became extremely influential, particularly in fisheries economics but also in the wider area of the economics of common-property resources. From the point of view of the history of thought it is of interest to note that many of his results had already been presented by the Danish economist Jens Warming (1911). However, Warming's article was published in Danish and failed to reach an audience beyond the Nordic countries, while his efforts to present his theory to a wider international audience came to nothing¹⁰.

Regarding exhaustible resources, we have seen that Jevons (1865) worried about the consequences of the exhaustion of Britain's coal resources. From a modern point of view, we might wonder why he did not take up the challenge of analyzing the optimal time pattern of exhaustion. One obvious answer is that the theoretical tools required had not yet been

¹⁰ The article has been translated into English by Andersen (1983). The story of Warming's work in fisheries economics has been told in the interesting article by Topp (2008), which also contains a biographical sketch. An interesting feature of Warming's work was that he analyzed the use of a competitive market for quotas as a means of bringing about optimal resource use in the fisheries.

assembled, although Jevons himself was to sketch the principles of utility maximization over time only six years later. Some beginning efforts to analyze this problem by the use of economic theory can be found during the next few decades, as e.g. the article by Gray (1914), where he analyzes the problem of exhaustion on the basis of Ricardo's (1817) theory of rent. But the great leap forward in this area was made in 1931 with the publication of Harold Hotelling's article on "The economics of exhaustible resources" (Hotelling 1931). He notes by way of introduction that the world's diminishing reserves of minerals, forests (sic) and other exhaustible resources have led to demands for the regulation of their exploitation – as John Stuart Mill had indeed called for almost a century earlier. As a background to his theoretical analysis he points out that

"[the] feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully has given rise to the conservation movement." (Hotelling 1931, p. 137.)

On the other hand, he argues, it is well known that some of the supply of these resources is controlled by monopolies, and that it is generally accepted that monopolies restrict output below the social optimum. This appears to contradict the feelings prevalent in the conservation movement and to call for a more rigorous theoretical approach. This has to move beyond the framework of the static theory of optimal resource allocation; indeed

"[problems] of exhaustible assets cannot avoid the calculus of variations, including even the most recent researches in this branch of mathematics." (Hotelling 1931, p. 140.)

The most famous result to come out of Hotelling's applications of the calculus of variation is his "rule" that under perfect competition the net price of the natural resource must grow at the rate of interest. He compared this equilibrium condition with the result derived from social welfare maximization, assuming that the welfare function took the form of time-additive discounted utility, and showed that the competitive equilibrium satisfied the optimality condition. Hotelling went on to examine a number of extensions of the model that would arguably move it closer to real-world conditions such as monopoly resource ownership, and he studied the implications of the model for economic policy. Altogether, this paper represents a major step forward in natural resource economics. At the time of its publication it may, given its advanced mathematics, have been too much ahead of its time to have significant effects on economic policy. In addition, the 1930s saw other priorities move to the forefront of policy debates; Keynesian macroeconomics drew more attention in the profession than the economics of natural resources. But with the increased attention to problems of resource scarcity in the 1970s, Hotelling's contribution got renewed attention in an economics profession which was now better prepared to absorb policy analysis couched in the language of the calculus of variations.

9. Paretian welfare economics and externalities

As Pareto's work became more widely known, it began to be explored and elaborated by some of the most prominent theorists of the mid-20th century, notably Samuelson (1947), Lange (1942), Little (1950) and Graaf (1957). However, when one reads these contributions from the point of view of modern environmental economics one is struck by the fact that externalities occupy a very insignificant place in them; externalities as a source of market failure was evidently not considered to be a central element of welfare theory. A related

point is that the typical exposition of welfare economics has much to say about the marginal conditions required for an optimum – as e.g. the equality of the marginal rate of substitution and the marginal rate of transformation – but little about the marginal conditions that emerge from utility and profit maximization in a competitive equilibrium¹¹. Obviously, however, it is in the comparison of these two sets of marginal conditions and in the analysis of the cases when “prices are wrong” that we find the starting point for the analysis of market failure. Another notable feature of the welfare economics of that period is that in the cases where externalities and prices are in fact being treated explicitly, the examples chosen for illustration, as the two agent case of the apple grower and honey-producer in Meade (1952), convey the impression that these are not very important issues for a modern industrial society to be concerned about.

A contribution which is significantly different in these respects is the article by Bator (1958). He explicitly links externalities to the failure of the competitive price system to capture all the costs and benefits that are relevant for a socially optimal allocation of resources. In addition, he introduces a separate category of externalities that had not been identified by previous writers, viz. the public goods type of externalities that could be related to the work of Samuelson (1954). Writing just a few years before the birth of modern environmental economics, Bator did not explicitly link this category to environmental externalities, and he also failed to explore the distinction between private goods with externalities on the one hand and pure public goods on the other.

The theory of public goods as first worked out in the framework of welfare economics in Samuelson’s articles from the 1950s is of obvious relevance for environmental economics.

¹¹ Samuelson’s justly famous chapter on welfare economics in his *Foundations* (Samuelson 1947) has no mention of market prices and individual optimization.

The cases of unspoiled natural beauty and unwholesome factory smoke, as discussed by Mill and Pigou respectively, fit directly into this framework, and so do our modern concerns about biological diversity and global warming. Environmental cost-benefit analysis is the practical application of the fundamental ideas in the theory of public goods. The optimality formula for the efficient provision of public goods requiring that the sum of the marginal benefits be equal to the marginal cost is reflected in the applied methodology of environmental project analysis.

However, Samuelson's analysis was limited to the case of pure public goods, and Bator's discussion followed along the same lines. In this case there is no conceptual distinction between individual and total consumption, and the individual agent has no – or at least extremely weak – incentives to provide a good whose benefits accrue to a large number of individuals but whose costs are carried by him alone. In the case of private goods with externalities there is a positive private incentive to consume or produce the good in question, but the individual has no incentive to take account of the additional costs and benefits – positive or negative - that arise for all other individuals in the community. Hence, there is the tendency for goods with negative externalities to be produced in an amount in excess of the social optimum, while goods with positive external effects will be underprovided. Cases of this kind received a lot more attention as the separate field of environmental economics developed during the 1960s and after. Modeling market failure in regard to the environment as a case where private goods production or consumption generated public goods type externalities, one could show that the Samuelson sum of marginal rates of substitution not only measured the benefits from public goods production

in the literal sense, but also the benefits generated by appropriately leveled Pigouvian taxes¹².

Thus, at the beginning of the life of environmental economics as a separate sub-discipline there was available a consistent framework for the analysis of market failure and corrective policies. The further development of welfare economics was marked by the advent of second-best tax analysis which among other things led to the literature on the double dividend. But by this stage we have proceeded to the present concerns of environmental economics and have advanced rather far from its early history. It is worth emphasizing, however, that the theory of public goods and externalities has shown remarkable robustness by allowing fruitful applications to environmental problems that have gradually ascended from the local level of apples and bees to the global problem of climate change, “the greatest market failure the world has ever seen” (Stern 2007).

A comment may be in order at this point regarding the relationship between environmental economics and public finance or public economics. Environmental taxation was discussed by Pigou in the 1920s and explicitly related to public economics issues in his *Study in Public Finance* (Pigou 1928). But in the following decades it received relatively little attention in the academic literature. A striking example of this neglect is provided by Musgrave’s famous treatise *The Theory of Public Finance* which summed up the status of the field at the end of the 1950s. This book devotes little more than a paragraph to Pigouvian taxation, and in this paragraph the environmental perspective is not even mentioned (Musgrave 1959, p. 115). A further curiosity is that the paragraph appears in a chapter entitled “The ability-to-pay approach.” This is in sharp contrast to today’s situation, where environmental taxation and

¹² This was e.g. made explicit in Sandmo (1975).

cost-benefit analysis are common and central themes for public finance and environmental economics.

The study of optimal environmental taxation and cost-benefit analysis is the application of welfare economics to public policy issues. The Paretian approach to welfare economics derives social efficiency and welfare from individual preference orderings or utilities. But this procedure may be problematic when it comes to the effects on individuals of consumption or production decisions whose consequences are hidden from the view of most people acting in their capacity as individual consumers and producers without specialized scientific information about the consequences of their private choices. That cases of this kind may call for deviations from the principle of consumer sovereignty was already noted by the philosopher and economist Henry Sidgwick who in his *Principles of Political Economy* (Sidgwick 1887) pointed out that governments did in fact try to protect its citizens from making unwise choices with regard to e.g. unhealthy or diseased food, unqualified physicians and hazardous industrial work processes. In his view consumer sovereignty, which he describes as “the fundamental assumption on which the economic rule of *laissez faire* partly rests,” should only be accepted as “a handy though rough rule of practical statesmanship” from which exceptions should be allowed in special cases. This view is reflected in many discussions of environmental problems since then, most notably perhaps in the contemporary debate about global warming¹³.

10. Concluding remarks

At the end of this very selective survey of the early history of environmental economics it is perhaps appropriate to ask whether we may conclude that environmental economics has an

¹³ An interesting historical discussion of this issue is Banzhaf (2011).

interesting past prior to the 1960s. My own conclusion – which may not come as a surprise – is that it does. There is much to learn from the early writings on environmental issues in a more specific sense, and also from the dependence of the growth of our discipline on the more general development of economic theory and methods.

What explains the growth of environmental economics from its early phase of scattered contributions on a diversity of topics to a full-blown field of specialization in the post-World War II period? This is a big and complex question that cannot be answered here. On the one hand, one could look for explanatory factors in the growth of environmental problems arising from increasing industrialization, energy use and the pressure of population. On the other hand one could also imagine that increasing standards of living, particularly in the industrialized world, has led to increased demand for environmental quality; the appreciation of environmental goods is income elastic. The interaction among these two sets of explanatory factors might go some way towards explain the increasing attention to environmental issues in economics.

However, this kind of explanation is not likely to be wholly satisfactory. Attention to environmental issues took a long time to get started in spite of the fact that environmental problems like those relating to sanitation and public health must have been pressing at the early stages of the industrial revolution. One of the causes of the lack of attention on the part of the majority of economists at the time is likely to have been the view that the quality of the environment was an issue that did not belong to the core of economics as a discipline. Another cause of the delay in the attention to problems of the environment must certainly be that the theoretical concepts needed to treat problems of market failure in regard to the environment took a long time to be established. What marks the transition to modern

environmental economics in the 1960s may therefore have been the realization in the profession that its tools of analysis had now reached the stage where they were adequate to the challenges posed by environmental deterioration. If correct, this is an interesting example of what Tjalling Koopmans described as the “interaction of tools and problems in economics”: “The solution of important problems may be delayed because the requisite tools are not perceived. Or the availability of certain tools may lead to an awareness of problems, important or not, that can be solved with their help.” (Koopmans 1957, p. 170.) This is certainly an angle from which the history of environmental economics may fruitfully be studied.

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